LETTERS TO THE EDITOR.

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The Deflection of Light during a Solar Eclipse.

It may be worth while to give my endeavour to obtain a rough value for the refraction effect of the atmosphere during a total eclipse of the sun. The simplest case possible is when the sun is in the zenith.

I will assume that the air density of the normal atmosphere has been removed, and that there is left the atmosphere which produces the abnormal effects in question. This is not necessary, but it makes the calculation somewhat simpler.

If O be the place on the earth's surface of maximum air density, the density ρ_0 of the residual atmosphere there will be one-seventieth of the density of the normal atmosphere if we assume that it corresponds to a fall of 4° C. in the atmosphere when in equilibrium. Take Ox in the direction opposite to that of the motion of the shadow, and Oy the vertical passing through the centre of the moon's disc. This assumes that the density is greatest at the centre of the shadow, which is almost certainly incorrect. I will take the density at any point of the residual atmosphere in the plane of xy to be given by

$$\rho=\rho_0(1-\kappa x)e^{-\beta y},$$

where β, although it varies with temperature, is assumed to be constant and equal to $1{\cdot}3\times10^{-6}$, distances being measured in centimetres. If we assume that the density of the atmosphere becomes normal at 150 miles distance from O, κ will be $4{\cdot}17\times10^{-8}$.

With these values of the two constants, the above formula expresses that the horizontal density gradient is uniform and independent of height, and that the atmosphere has its normal density at a distance of 150 miles. None of these statements is correct. The shadow-cone in the earth's atmosphere acts like a down-draught chimney or a kind of thermal air-compression pump, increasing the density in the central region of the shadow and diminishing it in surrounding regions. Thus κ may have a very much greater value than that given above, and, indeed, the factor $1-\kappa x$ may be quite incorrect in form.

However, taking this formula for the density, the index of refraction of the residual atmosphere at any point is

$$\mu=1+(\mu_0-1)(1-\kappa x)e^{-\beta y},$$

where $\mu_0=1{\cdot}000004$.

The path of any ray in the plane of xy might be got by solving the usual differential equation for this case, but I have not succeeded in getting a solution. However, the amount of the deviation can be obtained without knowing the actual path.

If ϕ be the angle which the tangent to a curve of equal refractive index makes with the axis of x, we have

$$\tan\phi=\frac{\partial\mu}{\partial x}\Big/\frac{\partial\mu}{\partial y}=\frac{\kappa}{\beta(1-\kappa x)}.$$

It can easily be shown that the radius of curvature of the lines of equal density or refractive index in the neighbourhood of the axis of y is muth greater than the radius of the earth. Thus, as we have assumed the earth's surface to be plane, we can assume these lines to be straight in the portion of the atmosphere concerned. On the axis of y, $\tan\phi=0{\cdot}032$, and for an observer at O the refraction of the light coming from a star near the edge of the sun's disc will be the same as if he were looking through an atmosphere stratified in parallel planes, making an angle ϕ with the horizon. A ray coming from such a star will make an angle of $\phi-15'$ with the normal to these planes, and the refraction will be

$$\begin{aligned}&(\mu_0-1)\tan(\phi-15')\\&=0{\cdot}000004\times0{\cdot}0277\\&=1108\times10^{-10}\text{ or }0{\cdot}023''.\end{aligned}$$

If the ray come from a star the angular distance of which from the sun's centre is 45′, the result is 0·0082″, which is a little more than one-third of 0·023″. But if, as I believe, κ has been greatly underestimated, the possible values of these refractions are much greater.

If the observer be not at the origin, but at a distance along the positive direction of the x-axis, the refraction of the light from stars on the other side of the sun's disc will not be away from the sun's centre, but towards it, and *vice-versa,* if he be on the other side of the origin. But no difficulty of this kind occurs for refraction in planes perpendicular to Ox if the position of the observer be on the x-axis. Perhaps it is worth mentioning that, from the only account of the observations I have seen, it appears that, with the exception of one star, all the changes in right ascension were of the same sign, whereas the changes in declination were all in the right direction.

I ought to mention in reference to Sir Arthur Schuster's letter (Nature, January 8, p. 468) that I never thought of a ray that, in its passage through the earth's atmosphere, lay partly inside and partly outside the umbra. And I thank him for correcting the slip that I made in the angular radius of the sun's disc. In these days of relativity, an error of fifteen minutes either of arc or of time is, perhaps, excusable.

Alexr. Anderson.

University College, Galway, January 14.

"The White Water."

It is possible that some readers of Nature can enlighten me on the cause and nature of what the Arabs call "The White Water." This phenomenon was witnessed by me on two occasions at the entrance to the Persian Gulf in the vicinity of the Quoin. On both occasions the time was about 8 p.m. There was no moon on the first occasion, but a moon on the second.

I first observed what appeared to be a line of breakers ahead of the ship; this was not possible because we were in deep water and the position of the ship was known. As we approached, it seemed that these supposed breakers were a succession of phosphorescent waves of a period of about sixty to the minute. The waves extended, so far as could be seen, for about two miles.

In addition to these waves there were also phosphorescent Catherine-wheels, both right- and left-handed, also phosphorescent light apparently coming to the surface and radiating out in all directions.

The phenomena lasted for about half an hour, gradually fading away, apparently sinking. There were strong atmospheric disturbances at the time. Both nights were clear and the sea was calm. I could obtain no local information. I may add, in conclusion, that I was not the only person who witnessed this display.

A. R. Palmer.

Portsmouth, January 13.

I hope that Capt. Palmer's letter will induce officers of the Indian Marine to investigate any cases of "White Water" that come under their notice. I am

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sure that the director and staff of the Indian Museum at Calcutta, where the collections of the I.M.S. investigator are deposited, will give them every assistance, and examine any specimens they may obtain. We want to know what are the organisms concerned in the production of the phosphorescence, and the physical conditions of the water in which they were living. The organisms can be strained out of the water by a silken or muslin net—or the hose turned to run through a piece of either cloth—and preserved in spirit or formic aldehyde (1 part in 30 of sea-water). They should be accompanied by exact information as to position, state of weather and moon, and temperature of the water; a sample of the actual water in a green beer-bottle would also be useful.

Phosphorescence so diffused as to make the sea appear absolutely white is, in my experience, rare. Indeed, I have seen "White Water" only on two occasions; the first halfway between Ceylon and Minikoi, on a dirty night towards the end of May, 1899 (heavy weather from south-west, maximum effect about 9.30 p.m., dark again by 11 p.m.); the second seen from Minikoi, about five weeks later, at the commencement of the Great Monsoon (south-west), time 9–10 p.m. A bottled sample of the water of the first showed only the same organisms as normally produce "sparks," but a tow-net sample of the second was so rich in the eggs, etc., of the organisms, which inhabit the slopes of Minikoi, and in breeding worms that normally bore into its corals, that I regarded it as perhaps a seasonal breeding phenomenon.

Waves of fire produced by myriads of sparks from minute water-fleas (especially Ostracods) and Protozoa are common in such tropical seas, but they merely mark the wind waves, and are not the same as the waves described by Capt. Palmer, which I think must be due to an optical effect. Globe or lantern-like effects produced by umbrella or barrel-shaped jelly-fish I associate with calm weather. They are most noticeable in the early part of the night, and do not usually last for more than an hour or two. As patches up to a few hundred yards across occur, and as the jelly-fish are sometimes so abundant that they can be collected in a bucket thrown overboard, the sea might be described as "White Water," but I am sure that this is not what the fishermen of the Indian Ocean know by that name. Fish passing through water highly charged with phosphorescent organisms frequently execute Catherine-wheels, etc., but fish themselves are often phosphorescent from bacteria living upon their skin. J. STANLEY GARDINER.

Zoological Laboratory, The Museums, Cambridge.

Proposals for a Plumage Bill.

PROF. DUERDEN'S letter in NATURE of January 15 might by its phrasing lead to the supposition that a few persons only are agitating for a novel Bill to prohibit the importation of plumage. The trade has been keenly opposed by all naturalists, not only in Great Britain, but also in the United States, Canada, Australia, and nearly every country in Europe for many years. The arguments now used were all urged by the trade when the Government Bill of 1914 passed its second reading in the House of Commons.

We are told that the introduction of another Bill will be "viewed with alarm in South Africa," although the ostrich-feather trade is a British Colonial industry carried on under totally different conditions from those of the trade in wild birds' (or "fancy") plumage. In December, 1913, the hon. secretary of the Ostrich Farmers' Association of South Africa, representing 1700 farmers, wrote to the Royal Society for the Protection of Birds as follows:—"My association has from time to time taken the feeling of its members on the subject-matter of the Bill about to be introduced by Mr. Hobhouse, and they have expressed their entire sympathy with, and approval of, the Bill. . . . The attitude taken up by the feather dealers in London is inexplicable to my association, and you have my assurance that they have not the least support from a single ostrich farmer in South Africa."

With regard to the "serious slump" said to have resulted from the Anti-Plumage Bill of 1914, it may readily be supposed that all such luxuries as feathers would suffer a slump during the war; but, as a matter of fact, one of the chief London brokers reported in 1915 that, "in spite of many difficulties, a large quantity of goods has been dealt with," and that there had been "a sudden improved demand from America." This demand followed the passing of the tariff clause prohibiting the importation into the United States of all "fancy" feathers.

Prof. Duerden himself reasons that decrease in "fancy" feathers would improve trade in ostrich feathers when he argues that the æsthetic tastes we have inherited from our barbarian ancestors demand that we should decorate ourselves with feathers of some sort.

The argument that we must encourage a French industry is also well-worn. It is true that the traders in Paris cried out in 1914 that the Hobhouse Bill was designed to protect the ostrich feather industry of the Cape at the expense of Parisian feather-dressers; but the Société d'Acclimatation de France replied: "The interests of workpeople will not be affected. . . . It is only a very small batch of speculators that can have to suffer. They are very rich."

Prof. Duerden has "grave doubts" whether the "ruthless destruction of birds" for trade can best be prevented by discouraging or prohibiting that trade. It is open to him to suggest a better way. The proposition that birds-of-paradise, lyre-birds, egrets, herons, trogons, orioles, terns, kingfishers, and all the rest of the feather-traders' victims, from albatross to humming-bird, might be "farmed" after the manner of the flightless ostrich, and plucked or killed for the market "in conformity with the highest humane demands," may be of interest to aviculturists; it has no practical bearing on the question of to-day. What science and humanity alike demand is immediate action to save the birds of the world from the ruthless and stupendous slaughter on which the trade now lives. L. GARDINER,

Secretary, Royal Society for the Protection of Birds.

23 Queen Anne's Gate, S.W.1, January 20.

THE suggestion made by Prof. Duerden (NATURE, January 15) for special breeding of birds as an alternative to prohibiting imports of their plumage is unacceptable to us for several reasons, but of these I need now only mention one, since this one appears to us conclusive. We hold that it would be impossible for the Customs to differentiate between the feathers of those birds which had been "farmed" and of those which had fallen victims to the ruthless plume-hunter. Prof. Duerden is, perhaps, unaware that a scheme similar to that which he adumbrates was advanced in 1914 by the Committee for the Economic Preservation of Birds, and was considered by the Government of the day to be unworkable.

The idea of our desired Bill being dangerous to the ostrich-farming industry has surprised us, previous Plumage Bills having been warmly supported by the

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